Solid Rocket Motor Asbestos-Free Insulation

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Substantial progress has been made to further develop and qualify an asbestos-free internal case insulation design for NASA's reusable solid rocket motor (RSRM). The presently used asbestos/silicon dioxide-filled, acrylonitrile butadiene rubber internal case insulation material is being replaced due to health hazard concerns and decreasing availability of all materials containing asbestos. The primary objective is to develop and qualify an asbestos-free internal case insulation design that will demonstrate similar or better erosion performance at a reasonable cost.

The first full-scale test with the two candidate materials was conducted on November 16, 1995, at the Thiokol Corporation Space Operations test facilities located in Utah. The RSRM flight support motor-5 (FSM–5) was used for this test. Aramid-filled, ethylene propylene diene monomer (EPDM) was utilized for both candidate materials. Both the 7 percent and 11 percent aramid-filled materials were installed in the high-impingement aft dome area. The 7 percent aramid-filled insulator was installed starting at the forward end of the aft dome and terminated 85 in forward of the nozzle boss (cylinder area). Erosion performance prevented the sole use of either candidate material in the high-impingement aft dome area adjacent to the submerged nozzle. The erosion performance of the 11 percent aramid-filled material was superior to that of the 7 percent material, as was anticipated from analysis of the subscale 48-in test motor data. In order to achieve the desired safety factors in the aft dome, it was necessary to use the present RSRM sandwich design with the 11 percent aramid-filled material replacing the substrate asbestos material next to the case wall. The currently used carbon fiber-filled EPDM adjacent to the propellant has a high cure shrinkage thus limiting the amount that can be installed.

Manufacturing and accurate analysis become much more difficult with the use of multiple layers of insulation. It is impossible to determine the exact prefire thickness of each of the multiple materials. Each material will undergo a different percentage of shrinkage during the cure cycle. A relatively large erosion data base is currently available with the presently used surface material thus enhancing reliability and confidence. The substrate material erosion rate must be estimated based on the one (FSM–5) full-scale motor test. If the substrate material is occasionally penetrated during the test, any statistical analysis is of little value. It is impossible to determine the exposure times or exact erosion for each material.

Analysis of the 7 percent aramid-filled material in the cylindrical area of the FSM–5 test indicated that this material will perform satisfactorily as a sole insulator for the entire motor except for the aft dome. Erosion performance was predicted for the untested portion of the motor using ratios from previous RSRM data. The erosion performance predictions for both of the asbestos-free materials will be evaluated with three additional full-scale motor tests prior to the first Shuttle flight.

Data evaluation methodology with a limited data base remains an undesirable and somewhat unique situation. The cost of full-scale testing precludes an adequate number of tests for standard statistical evaluation. Subjective decisions are necessary to determine which analysis technique will produce a reasonable design with an acceptable risk. Thiokol and NASA engineers agreed that erosion performance analysis using median material losses plus three standard deviations would be a reasonable approach to establish initial design thickness limits. It was further stipulated that the minimum design thicknesses would be no less than the maximum losses (with appropriate safety factors) experienced at any measurement station.

Erosion performance data for the two asbestos-free internal case insulation materials described above should be useful information for anyone associated with solid rocket motor design and performance evaluation. All component systems will have to be asbestos-free in the near future. The subjective nature of the methodology is unavoidable due to the unique circumstances. Further static testing and subsequent Space Shuttle flight evaluation will verify the validity of the analytical technique utilized.

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Industry Involvement: Thiokol Corporation Space Operations

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